



SOUTHWEST FISHERIES CENTER

NATIONAL MARINE FISHERIES SERVICE

SOUTHWEST FISHERIES CENTER

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MAY 1991

WORKSHOP REPORT:
SURVEY DESIGN REVIEW PANEL:
ETP DOLPHIN MONITORING PROGRAM

By

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WORKSHOP REPORT:

Survey Design Review Panel:
ETP Dolphin Monitoring Program

10-11 July 1990
Southwest Fisheries Science Center
La Jolla, CA 92038

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ABSTRACT

A scientific review panel was convened in a Survey Design Workshop at the Southwest Fisheries Science Center in La Jolla, CA on July 10-11, 1990. Panel members were asked to review research related to ongoing shipboard observer programs designed to aid in monitoring of dolphin stocks affected by the tuna purse seine fishery in the eastern tropical Pacific Ocean. Based on this review, panel members were then asked to make recommendations about future survey designs. Both research and commercial vessel observer programs were considered during the review process.

Reviewers concluded that research vessel observer data (RVOD) are most useful for estimates of absolute abundance, while tuna vessel observer data (TVOD) are most useful for estimates of trends. RVOD are better sources of absolute abundance estimates because the time period covered is relatively short and the survey effort is predetermined and under our control. TVOD are better sources of trend estimates because these data have much greater spatial coverage, allow for fine-scale post-stratification, extend over a much longer period of time, are much more numerous. In addition TVOD are considerably less expensive than RVOD to collect.

Primary recommendations for future work were to 1) continue deriving trend estimates from tuna-vessel observer data, 2) develop calibration systems that will relate TVOD to RVOD, and vice versa, and 3) to intersperse research vessel surveys of the full fishery area with single-year surveys targeted to derive minimum abundance and/or absolute abundance estimates of specific stocks determined to be in jeopardy or to be incompletely surveyed by the existing MOPS (Monitoring of Porpoise Stocks) research vessel survey design.

OBJECTIVE

Workshop objectives were to review existing research programs and recommend alternatives for dolphin population survey and assessment in the eastern tropical Pacific Ocean following the end of the current survey program (MOPS) in 1991. Panel members were asked to base their recommendations on information presented in 10 manuscripts submitted for review prior to the meeting. The primary goal of the meeting was to reach a consensus on the most effective plan for future surveys, given the goal of continued monitoring of dolphin stocks for management purposes.

ABSTRACTS AND REVIEWERS COMMENTS

1) MOPS ESTIMATES 1986-1990: Figures only, no abstract

Primary results were an unexpected and biologically unlikely increase in relative abundance estimates for northern offshore spotted dolphins, eastern spinner dolphins and northern whitebelly spinner dolphins, coupled with continued high variability between years in estimates for all stocks of common dolphins.

Reviewer comments. Reviewers suggested that MOPS (Monitoring of Porpoise Stocks) data were probably used most effectively as a source of absolute abundance estimates rather than as a basis for trend estimates because the current 5-year time series is too short for deriving meaningful estimates of changes in population size. In contrast, they suggested that TVOD were probably most useful as a trend index because of the long time-periods available for analysis, but that TVOD would be relatively poor as a source of absolute abundance estimates. Burnham suggested that surveys could probably be conducted in alternate years rather than annually without much loss of efficiency given the apparently small rate of change for most dolphin stocks.

Reviewers felt that in light of the biologically implausible series of estimates derived to date during MOPS, the MOPS analysis methods needed review and probably improvement. Reviewers suggested that incorporating environmental information and determining some method of calibrating between research and commercial vessel data might significantly improve the estimates.

2) SIMULATION MODEL EVALUATION OF MOPS SURVEY DESIGN:

MOPS in TOPS:

effects of

tracklength, environment, and non-random school distributions
on line transect estimates of dolphin school abundance
derived from research surveys

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ABSTRACT

A mathematical simulation model (TOPS) testing the efficacy of an ongoing line transect survey of dolphin abundance in the eastern tropical Pacific Ocean (MOPS), showed that reasonably precise and accurate estimates of dolphin school abundance could be derived using current sampling levels, even under conditions of relatively limited sampling effort, strong environmental heterogeneity, and markedly non-random, nonstationary distributions of dolphin schools.

Simulation results verify theoretical assertions that adequate estimates of abundance for non-randomly distributed, non-stationary (but relatively slowly moving) objects can be derived from line transect surveys provided transects are chosen randomly with respect to the sighted objects, biases remain consistent, sampling artifacts are minimal, and provided sampling levels are sufficient. As sampling levels decrease, violations of assumptions become increasingly important.

Reviewer comments. Reviewers suggested simplifying the description of model development and focusing discussion more closely on the general results and implications of the model, rather than drawing specific conclusions about the MOPS survey.

The modeling approach in general was not well-received by some reviewers, who felt that the conclusions presented in the manuscript were unwarranted in light of the relatively unrealistic environmental topographies and movement rules used. These reviewers suggested that the model would be improved significantly by revising these aspects and by incorporating more of the factors that affect real-world data. Specific suggestions included 1) using the same methods used in the analysis of MOPS survey data (e.g., fitting perpendicular distance functions), 2) varying school sizes and school clustering, 3) devising topographies with elongated areas of concentration, 4) allowing the research ship to leave the track line during sightings, and 5) changing topographies from year to year.

3) CHARACTERISTICS OF MOPS ANALYSES:

INVESTIGATING PARAMETERS AFFECTING RELATIVE ESTIMATES OF DOLPHIN ABUNDANCE IN THE EASTERN TROPICAL PACIFIC FROM RESEARCH VESSEL SURVEYS IN 1986, 1987, AND 1988.

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ABSTRACT

The National Marine Fisheries Service completed three research vessel surveys in 1986, 1987, and 1988 to monitor trends in the abundance of dolphin stocks that may be adversely affected by purse seine fishing for tunas in the eastern tropical Pacific. Line transect analysis formed the basis for estimating stock- and year-specific abundance indices. Various methods of calculating the stock-specific abundance index were investigated. These included 1) using the mean versus the median estimate of school size, 2) including or excluding small schools, 3) weighting school size estimates, 4) using sightings data that are either truncated or untruncated, 5) using sightings from all dolphin schools, target schools, or a particular species, and 6) pooling or stratifying sightings and school size data. Relative abundance estimates and variances for all target stocks for each year are presented. The following set of parameters was selected as maximizing the power of a trend analysis: 1) school size estimates were averaged over all observers and were not weighted, 2) only schools of 15 or more animals, encountered within 3.7 km of the trackline during Beaufort sea states of 0-5, were used in the analysis, 3) all dolphin schools encountered within these parameters were used (i.e., sightings were not restricted to schools of target species or particular stocks), and 4) sightings were pooled over geographic strata. There were no significant trends in the population index for any of the dolphin stocks; however, the power of this statistic after only three years is unacceptable. The coefficient of variation was between 16 and 19% for spotted dolphins, 20 and 21% for spinner dolphins, and 24 and 29% for common dolphins.

Reviewer comments. Holt opened discussion by noting that the most desirable analysis would provide estimates by stock and area, but that data were too sparse for this approach. The MOPS surveys were designed to detect over 6 annual surveys a 40% reduction in abundance of spotted dolphins (the stock suffering the majority of fishery-related mortality) only. Estimates for other species, e.g., common and striped dolphins, were not foci of the survey planning process. The primary criterion for MOPS survey design was to derive the smallest possible CV (coefficient of variation) for indices of spotted dolphin abundance.

Considerable discussion ensued about the methodology of MOPS. Buckland expressed concern about the pooling methods used, pointing out that the current method would predict, for example, an overall density of 1 in each of two areas, given data indicating density = 0 in area 1 and density = 2 in area 2. This apparently results from estimating stock densities based on simple proration of species densities. Buckland suggested that presenting stock estimates was inappropriate, as the data really show only trends for species. Holt responded that he chose to pool the data because trends for pooled stocks (e.g., northern and southern offshore) paralleled each other and CVs were lower for pooled than for stratified data.

Wade subsequently pointed out that stock trends paralleled species trends because only the parameter for area (A_{ijk}) and the calculations for stock overlap areas contain the stock index (j) in Sexton *et al.*'s equations. Trends for any two or more stocks from any single species are perforce parallel because the A_{ijk} do not change between years. Therefore, Sexton *et al.*'s analyses have not inspected whether independent estimates of trends for stocks within species are parallel. This issue is distinct from that of "pooling" or "stratifying" by geographic areas.

Goodman opened a discussion of the appropriate sampling unit by commenting that the section describing bootstrap methods should be expanded to make more clear the fundamental sampling unit. Using days as effort units was suggested. Holt defended the "effort leg" as the fundamental unit, because the "effort leg" is by definition a time period of constant conditions. Conditions can change markedly within days, as sighting conditions and densities change. Burnham and Goodman suggested comparing bootstrapped estimates derived using days as the sampling unit versus using legs as the sampling unit. Buckland pointed out that using the smallest resampling unit practicable without increasing variability was the best strategy. Hall suggested checking whether the distribution of leg lengths remained constant from year to year.

Goodman questioned the difference between trackmiles "traveled" in bootstrap samples and the actual trackmiles covered each sampling period (year). Wade commented that inter-annual differences in survey effort between years was on the order of 5-10%. Reviewers suggested that this be checked more carefully, noting that where variances of bootstrap samples are greater than observed differences year-year, the bootstrap is probably mimicking the wrong sample size.

Buckland suggested pooling data across years within species to increase sample size, rather than pooling across species within a year. Holt disagreed, maintaining that pooling across species should be less biased than pooling across years because animal behavior should be consistent year to year. Wade reported that he found little difference between years in $f(o)$ for particular

species in his analyses of RVOD, although the frequency distributions of sightings did change year to year. Reviewers agreed that $f(o)$ characteristics should be compared across years and species, to determine whether pooling is justified.

Reviewers expressed concern that perpendicular sighting distances were much larger in TVOD than in RVOD and that observers on research vessels may be guessing at the sighting angles after seeing a cue and then losing it briefly. Additional analyses were recommended of differences between sighting angles in RVOD and TVOD. Wade commented subsequently that sightings from TVOD, in particular those used in his analyses, include sightings made by helicopters (i.e., made farther from the vessel than sightings possible by observers on board ship using binoculars).

Several reviewers commented about strategies for selecting truncation points, in particular truncation distances for sightings data and Beaufort truncation levels. Burnham and Buckland agreed that a distance of 6 km was probably appropriate. Reviewers commented that truncating at 6 km would eliminate only 3-4% of the sightings and should also eliminate the problem of anomalous "clumps" far from the trackline, in the frequency distributions of sightings data versus distance from the trackline. Burnham suggested that truncation should also help improve the precision of school size estimates because it would eliminate those schools sighted but not investigated because their perpendicular distance to the trackline was too great. Wade pointed out that school sizes are rarely estimated for schools not investigated. Burnham stressed that good estimates of average school size are important because changes in school size would affect directly estimates of dolphin population size.

Buckland pointed out that TVOD data are truncated above Beaufort 3 while RVOD are truncated above Beaufort 5. Holt commented that RVOD samples sizes are too small if data are truncated below Beaufort 5. Wade commented subsequently that 18-25% of MOPS effort occurred in sea states of Beaufort 5 during 1986-1989; about 30% of total MOPS effort occurs in the western area, where Beaufort 5 is common. Buckland suggested that Beaufort state be used as a co-variate. Palka commented that she was investigating this problem as part of her thesis research.

Problems associated with school size estimation were discussed at length. Burnham noted that changes in calibration coefficients with weather, area, etc, were possible but unquantified. Hall suggested that comparing histograms of school size estimates in different years might be very useful. Reviewers suggested that

Michael Scott's¹ finding of changes in school size with time of day in TVOD, should be investigated in RVOD as well.

Much discussion involved the problem of including or excluding small schools from analyses. At present, schools smaller than 15 animals are excluded from the analyses. Small schools are a problem because many of them are unidentified to species, or if they are identified, are non-target species. Buckland recommended including small schools of target species (with stratification by school size if possible) and excluding non-target schools. The problem with including non-target schools is that these schools, which tend to be the majority of small schools, often have different sighting characteristics (i.e., narrower strip widths) than target schools.

With respect to weighting of school size estimates, reviewers noted that weighting by the reciprocal of the square root of school size was an ad hoc method that may not be appropriate because it duplicates the effect of truncating by school size. Burnham recommended using instead a regression-based or co-variate weighting factor, which should be especially effective for mixed schools.

4) STATISTICAL POWER OF MOPS ANALYSES:

Power analysis of dolphin surveys in the eastern tropical Pacific

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ABSTRACT

A power analysis of continued research vessel surveys for dolphins affected by the purse-seine tuna fishery in the Eastern Tropical Pacific (ETP) shows that the probability of detecting declines in abundance is low without substantial long-term effort. At the present survey level effort of 2 ships and 240 sea days per year, the minimum rate of decrease we can expect to detect at the conventional significance level of $\alpha = 0.05$ is 19% per year during a 6-year study period. Such a rate of decrease would mean that only 27% of the initial population would remain at the end of the study period. Surveys taken every 2nd or 3rd year are able to detect smaller annual rates of decline, but the surveys must be carried out over a longer time period. The ability to detect

¹Michael Scott, Inter-American Tropical Tuna Commission, c/o Scripps Institute of Oceanography, La Jolla, CA. 1991. MS in preparation.

declines in dolphin abundance is computed to be lower than initially estimated when the present MOPS surveys began. The main reasons are that (1) these calculations are based on an average for all target dolphin species, rather than only on spotted dolphins, and (2) the former calculations were based on 240 actual sea days of mammal sightings, whereas in practice fewer than 240 days are available due to various factors.

Reviewer comments. DeMaster asked reviewers their opinion of selecting $\alpha = \beta = 0.1$ for power calculations. Goodman pointed out that the choice of a specific level for α or β was a policy issue, not science. Simply reporting whether the trend (slope) was positive or negative might be sufficient.

Reviewers reiterated that only RVOD were capable of producing reliable estimates of absolute abundance. Reilly pointed out that estimates of absolute abundance would be required to derive estimates of maximum allowable take. Hall pointed out that using RVOD for absolute abundance estimates will require re-analysis of the MOPS data, to determine and remove the bias(es) responsible for the observed unrealistic changes in the index. He suggested changing the focus of the MOPS analyses from reducing variability to reducing bias.

Reviewers suggested that RVOD should be used for estimating absolute abundance and for setting quotas, and that detecting trends in abundance would take longer than the proposed 6 annual MOPS surveys. Hall pointed out that expression of time lags in population response to changing conditions would likely take longer than 5-7 years.

Reviewers agreed in general that annual surveys were over-zealous. Surveys conducted less frequently over longer periods of time would be sufficiently effective and much less costly provided overall trends are small enough that the population is not in danger of decreasing critically during inter-survey periods.

5) SIMULATION MODEL EVALUATION OF TVOD ANALYSES:

**Effects of Non-randomness
on Line Transect Estimates of Dolphin School Abundance**

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ABSTRACT

Line transect analysis is a census method that has been used to derive estimates of dolphin school abundance from sightings data collected by observers on tuna purse-seine vessels. The method is based on the assumption that movements of the sighting platform (tuna vessel) and sighted objects (dolphin schools) are random with respect to each other. In practice, neither schools nor vessels move randomly. Stratification of sightings data has been used to partially alleviate the effects of this non-randomness but the effectiveness of this stratification cannot be tested with data from commercial vessels because the movements of the vessels cannot be controlled.

As an alternative, we have used a relatively simple mathematical simulation model to investigate the severity of bias introduced in school abundance estimates by non-random movements of schools and vessels, and by the data stratification procedure. Simulations show that non-random movements on a scale of a few hundred miles, coupled with the data stratification procedure, can lead to overestimates of dolphin school abundance by as much as a factor of two. These results focus attention on the need to understand patterns of dolphin school distribution in smaller scales of space and time than have been studied previously, and to develop data stratification methods more resilient to the effects of small-scale non-randomness.

Reviewer comments. Reviewers commented that the data smoothing procedure tested in the model and found to be troublesome has been modified in subsequent analyses of tuna vessel observer data. Reviewers also suggested several refinements that should be included in future modeling efforts, reiterating some suggestions that had been made in reference to MS #2 (MOPS in TOPS) as well as contributing new suggestions. Specific suggestions included 1) investigating differences in search behavior and success of tuna vessels with the use (or not) of new types of radar equipment, and 2) changes in fishery focus (e.g., search patterns and areas of fishing) with changing legislation (e.g., avoiding dolphins due to "dolphin safe" procedures).

Reviewers also commented that comparing pairs of years was not truly analogous to estimating trends from data collected over a series of years, suggesting that more "years" of simulations be included in a simulated trend analysis before drawing conclusions. Reviewers again suggested that other types of topographies be investigated, in particular the effects of linear or oblong topographies such as apparent along 10°N in the ETP, and topographies with less precipitous slopes. Reviewers commented that the parameters controlling the concentrations of effort were chosen arbitrarily, and recommended conducting sensitivity analyses of these parameter choices.

6) STATISTICAL POWER OF TVOD TREND ANALYSES:

Statistical power and detectable trends in estimates of dolphin abundance derived from tuna vessel observer data

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ABSTRACT

We evaluated in two ways the statistical power of estimated trends in abundance of dolphins affected by the tuna purse-seine fishery in the eastern tropical Pacific Ocean. First, we calculated statistical power for cases where weighted linear regression across 5-year series detected no significant trend ($P > 0.10$). Second, for these same cases, we calculated the amount of change that would have had to exist for detection at $\alpha = \beta = 0.10$, given observed variability in the data.

Power tended to be low in general, but highly variable overall, due to the relatively large and variable coefficients of variation associated with individual estimates of abundance. Power was highest for the group with lowest coefficients of variation (e.g., northern offshore spotted dolphins; average estimate of power approximately 0.4) and lowest for the stocks with most variable data (e.g., eastern spinners; power about 0.1).

Calculations of the trend that would be detectable, given reported CVs and abundance estimates, and assuming $\alpha = \beta = 0.1$, showed in general that the large size of the CVs obscured all but very strong trends. Detectable trends ranged from a minimum of 16% per year for northern offshore spotted dolphins to a maximum of 40% per year for central common dolphins.

Large inconsistent changes between years in abundance estimates coupled with weighted regression methods further decreased ability to distinguish statistically significant trends in abundance using TVOD.

Reviewer comments. Reviewers concluded that the 5-year intervals tested in these analyses are probably too short to be meaningful, but also pointed out that longer intervals are more likely to include nonlinearities which will have to be considered. The analyses discussed here assume linear trends.

Reviewers also discussed, but did not solve, the policy problem of deriving a decision rule that would define the tolerance (e.g., 5%) for non-detection of a real decrease in abundance of some amount (e.g., 20%) over some specified time period (not necessarily 5 years) given some specified statistical design. The real problem is determining which decision criterion is consistent with desired or observed performance.

Reviewers then discussed the concept and problems of combining research vessel (RVOD) and tuna vessel (TVOD) data sets. Suggestions for combining data included 1) combining after deriving estimates of some sort from each data set (e.g., averaging the slopes from each data set), weighting each term by the reciprocal of its CV, and 2) sequential analyses (hierarchical).

Reviewers discussed but rejected the concept of a hierarchical framework for combining TVOD and RVOD, favoring instead calibration studies between RVOD and TVOD, followed by standardization. Burnham pointed out the unpleasant possibility that calibrations may not remain consistent over time.

In general, reviewers felt that the only effective way to derive a combined estimate from both TVOD and RVOD would be to estimate trends (slopes) independently for each data set, then derive a combined estimate weighted by the reciprocal of each slope's variance. Reviewers generally were not in favor of deriving some of the parameters for line transect analysis from one data set (e.g., TVOD) and some from the other (e.g., RVOD), then combining the mixed parameters.

7) SIMULATION MODEL EVALUATION OF CHARTER SUGGESTION:

CHARTOPS: simulating short-term charter of a tuna purse-seine fleet to survey dolphin schools

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ABSTRACT

Simulation model results show that short-term charters of the eastern tropical Pacific tuna purse-seine fleet to survey dolphin schools can be a very ineffective procedure for deriving estimates of dolphin school abundance. Simulations stopped fishing operations simultaneously for the entire fleet and commenced survey procedures for the subsequent 24-hr period. Results showed high and variable estimates of school abundance during the first 12 hours, and generally low but still variable estimates during the second 12 hour period. The high estimates during the first period resulted from the concentration at that time of tuna vessels in areas of high school density. The low estimates from the second 12 hour period resulted from an interaction between the spacing and size of dolphin school patches and the speed of tuna vessels, such that during the second 12-hr period tuna vessels tended to have left their original concentrations of dolphins but not to have entered a new concentration.

More complicated chartering schemes might be more effective, but in any case, the effectiveness of any scheme will be affected strongly by the (unknown) true spatial and temporal distribution of dolphin schools. The fundamental problem with any scheme will be the initially non-random (but unquantified) distribution of tuna vessels with respect to the distribution of dolphin schools.

Reviewer comments. Reviewers agreed that the charter idea as expressed in this model would be ineffective even with different starting distributions of schools and boats, primarily because the boats and schools would not be randomly distributed at the start of the experiment. Buckland suggested that a more effective way to increase research-vessel type data might be for interested countries (including the US) to consider a joint, coordinated survey similar to MOPS, but using more than two vessels.

8) SIMULATION MODEL EVALUATION OF DENSITY DEPENDENT EFFECTS:

Using the TOPS model to determine the ability of research and tuna vessels to reflect decreases in dolphin density when the school's spatial distribution is density dependent.

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ABSTRACT

The TOPS computer simulation was used to evaluate whether the tuna and research vessel's sampling and analysis methods were able to track over 6 years a constantly decreasing dolphin population when the spatial distribution of the dolphin schools was density dependent. The population decreased by a constant 10% of the first years abundance.

Both the tuna vessel and research vessels' procedures were able to closely follow the 10% linear decrease. However, the tuna vessel procedure over-estimated the abundance, while the research vessel procedure under-estimated the abundance. The bias and variability of the estimates made from the research vessel procedure were smaller than those of the estimates made from the tuna vessel procedure. Consequently, the research vessel procedure had greater power in detecting a given level of change in population size (96% versus 75%, respectively).

The estimated abundance of dolphins as calculated from the research vessel's procedure was not changed by increasing the amount of time spent at each sighting (up to one hour) or by excluding schools with less than 15 animals from the analysis method. In fact, the estimated individual dolphin abundance was statistically indistinguishable from the actual dolphin abundance.

However, the estimated abundance of schools as calculated from the research vessel's procedure was improved by decreasing the amount of time spent at each sighting and by including small schools in the analysis method. Only in the case where small schools were included in the analysis was the estimated school abundance statistically indistinguishable from the actual school abundance; in all other cases, the estimated school abundance was lower than the actual abundance. Only in the case where there was one hour of processing time per sighting was the estimation method unable to track the 10% linear decrease in school abundance; in all other cases, the research vessel's procedure could closely track the decrease in school abundance.

Reviewer comments. Reviewers commented that year to year variability in environmental conditions, not included in the model,

might obscure trends. For example, changes in the intensity and spatial distribution of dolphin school aggregations might compromise ability to detect trends. But reviewers pointed out also that the really large changes such as those generated by the El Niño of 1983 could probably be defined easily enough to be incorporated explicitly in trend estimates. The effects of environmental changes would probably be more easily detected in TVOD, because these data are so much more numerous.

Reviewers were concerned about the potential problem of research vessels being drawn into clusters of schools if vessels do not return completely to the trackline after a sighting. They recommended strongly that a complete return to the trackline is necessary, and recommended examining existing MOPS data to see whether such an effect might be apparent in sequential sightings.

Hall mentioned that estimated school sizes in TVOD appear to be smaller in areas of high fishing activity, suggesting the possibility that school sizes should perhaps be modeled as a function of fishing effort. Presumably schools break up during a chase and remain fragmented afterward. Reviewers recommended that existing data be examined for this effect; if found, it should be incorporated into the simulation analyses.

9) DIRECT COMPARISONS OF RVOD AND TVOD:

A COMPARISON BETWEEN NMFS TUNA VESSEL AND RESEARCH VESSEL DATA ON DOLPHINS IN THE EASTERN TROPICAL PACIFIC: SCHOOL SIZE, ENCOUNTER RATE, $F(0)$, AND ABUNDANCE ESTIMATES

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ABSTRACT

NMFS tuna vessel (TV) data are compared with NMFS research vessel (RV) data collected on dolphins in the eastern tropical Pacific from 1986-88, using only tuna vessel data collected at the same time of year as the research vessel data (July 28 to December 10). Estimates of TV and RV encounter rates (number of schools detected per 1000 nm) are calculated by 5° latitude and longitude cell within a year for comparison for 4 species: spotted (*Stenella attenuata*), spinner (*S. longirostris*), common (*Delphinus delphis*), and striped (*S. coeruleoalba*) dolphins. Estimates of TV and RV mean school sizes are calculated by 5° cell within a year for comparison for two species: spotted and spinner dolphins, and for two stocks within those species: offshore spotted and eastern spinner dolphins. TV and RV frequency distributions of school

sightings over years and 5° cells. Hazard-rate models are fit to TV and RV perpendicular distance distributions for spotted and for spinner dolphins for the estimation of $f(0)$ (detection probability density function evaluated at zero) using sightings pooled over years and 5° cells. Using line-transect methods, TV and RV abundance estimates for spotted dolphins and for spinner dolphins are calculated by 5° cell, using the encounter rates and mean school sizes of a 5° cell with the pooled estimates of $f(0)$.

TV encounter rates by 5° cell are significantly lower than RV encounter rates for common and striped dolphins, but not for spotted and spinner dolphins. TV mean school sizes by 5° cell are significantly greater for spotted and for spinner dolphins and for the stocks of offshore spotted and for eastern spinner dolphins. TV and RV school size frequency distributions are significantly different for the 4 species and the 2 stocks. TV and RV estimates of $f(0)$ are significantly different for spotted and for spinner dolphins. TV and RV estimates of abundance by 5° cell are significantly different for spotted dolphins but not for spinner dolphins.

Reviewer comments. Reviewers questioned whether Beaufort levels included in the analysis were the same for both data sets. They suggested quantifying the number of sightings in Beauforts 4 and 5 in TVOD, and comparing that to RVOD. Wade pointed out that a more appropriate and direct approach would be to compare the percent of total effort expended by each platform type within each Beaufort type.

Hall suggested that non-US data, and the remainder of the US data, will be helpful in "filling in" areas where data were sparse for Wade's analysis, in particular south of 5°S. Hall also suggested examining data from 1989 for differences between the years, to increase the size of the data set if no differences were found. Buckland objected to the statement that RV estimates were more reliable than estimates derived from TVOD, reiterating that MOPS stocks estimates simply expands species estimates as a function of area inhabited. Buckland commented that RV data are more reliable than TVOD, but may be too sparse to yield reliable estimates. The high variances associated with stratifying the data by 5° cells prompted Buckland to suggest changing the stratification scheme to create a window for comparison around the RV track, i.e., develop a "swath" analysis that would allow for elongated search tracks.

Goodman suggested that the inability to predict RV encounter rates from TV, or vice versa, and the differences between the variances of each suggests the need to quantify in some manner the reliability of encounter rate estimates from the respective platforms. Burnham suggested doing this by assuming counts (encounters) are Poisson by effort; thus one could assume Poisson

effort in each cell, estimate expected variance in each cell, and compare expected with observed variances.

Hall commented that times and positions when school encounters were recorded should be re-examined, reiterating that heavy fishing could cause large schools to split into smaller units, thereby increasing the number of schools available for encounter in these areas.

Goodman noted that RV estimates are essentially the smeared estimates of 1-6 observers, while TV estimates are usually made by only one observer. He suggested that some provision be developed for making the data more comparable, perhaps by generating some sort of artificial smearing for the TV data. Wade pointed out that the modal number of research vessel observer estimates for each school was 3; the next most common number being 2.

Hall pointed out that another source of differences between RV and TV data may be that fishing areas have changed since 1986, extending further south. Buckland pointed out that several explanations exist for the observed differences in school sizes between RV and TV; for example, large schools of tuna may selectively accompany large schools of dolphins. Barlow pointed out that there were no cases where TV estimators of SS were smaller than RV estimates.

Reviewers noted that estimates were best for spotted dolphins, much less reliable for commons and striped dolphins. Although coverage for common dolphins has increased greatly with Mexico's co-operation, data for striped dolphins are still very sparse in TVOD (especially compared to RVOD). In addition, the great differences between areas in fishing effort on commons (and also in the effort expended by different country's fleets) led Hall to recommend that special monitoring efforts ought to be directed specifically toward the stocks of common dolphins, in order to improve estimates.

10) ENVIRONMENTAL INFLUENCES ON DOLPHIN DENSITY ESTIMATES:

SEASONAL CHANGES IN DISTRIBUTION AND HABITAT DIFFERENCES AMONG
DOLPHINS IN THE EASTERN TROPICAL PACIFIC

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ABSTRACT

Large-scale patterns of dolphin distribution and oceanography were studied from research-vessel surveys conducted in the pelagic eastern tropical Pacific during Jun-Nov in 1982, 1986 and 1987. Substantial changes were observed in relation to previously reported winter distributions for spotted and/or spinner dolphin schools (Stenella attenuata and/or S. longirostris) and for striped dolphin schools (S. coeruleoalba). These dolphin species were sighted in abundance west of 120°W along 10°N coincident with seasonal shoaling of a thermocline ridge occurring there. No seasonal distribution changes were observed for common dolphin schools (Delphinus delphis); as in the winter, they occupied upwelling-modified waters of the region. Highest-density areas for the three school types were clearly separated spatially, and the thermocline depths and sigma-t's of sighting localities were statistically different between spotted/ spinner dolphin schools and common dolphin schools. Striped dolphin schools could not be discriminated from the other two types based on these habitat variables, indicating other factors or processes contribute to the observed spatial separation of the three distributions.

Reviewer comments. Reviewers suggested using the environmental data in a stratification scheme. Buckland suggested stratifying, and/or using a co-variate approach (perhaps within a stratum), assuming a constant $f(o)$, and estimating stratified school sizes, species proportions, and encounter rates taking into account unequal search effort, and small sample sizes in some areas. He also suggested developing different schemes for different species.

Reviewers also advised that the software used to generate the analyses should be available down to source code. Remote sensing data were proposed to augment the environmental data collected during MOPS, but problems with cloud cover along 10°N and seasonal variability during the survey period mean that satellite data can't be used to pre-stratify the data. Hall suggested using satellite data, where possible, to fill in areas not covered by the research vessels during the survey period.

CONCLUSIONS AND RECOMMENDATIONS

There was consensus among the Survey Design Group members that the core programs for monitoring changes in dolphin abundance should continue for at least another five year period. However, some members expressed strong reservations about the ability to manage all dolphin populations solely on the results of "significant trends" in relative abundance. Reviewers concluded that statistical power of existing analyses for several of the species (i.e., common dolphins and striped dolphins) was either marginal or inadequate, while for the main two species in the fishery (i.e., spotted and spinner dolphins) power was adequate for management purposes.

Therefore, the Survey Design Group endorses the general approach recently proposed by the IATTC and the Service, whereby international quotas be established and enforced on an annual basis. To this end, the Survey Design Review Panel recommends that the protocol for the annual research vessel surveys be changed as follows:

1. Conduct in alternate years, surveys similar to the MOPS surveys. These surveys should cover the entire study area, as presently. Two research vessels, each surveying for 90-120 sea days, should be used in these surveys.
2. Each year following a MOPS-type survey, a survey designed to estimate the absolute or minimum number of animals in a stock should be carried out. Those stocks which are currently assessed insufficiently (characterized by data with low power, high variability, e.g., common dolphins) should be surveyed first. Two research vessels, each surveying for 90-120 sea days, should also be used in these surveys.

In addition to recommending a continuation of annual research vessel surveys, the Survey Design Review Panel recommends that the following activities be completed within the next two years:

1. The specific analysis methods for data collected from research vessels should be finalized and the data from the first five MOPS cruises should be analyzed.
2. Based on the above analyses, variances of annual abundance indices should be used to calculate power of detecting total decreases in abundance, during the survey period, on the order of 20%.
3. Based on the above analyses, a method for combining the results of the research vessel and tuna vessel analyses should be developed.

4. Based on the above analyses, the Service should determine how its management strategy will reflect the information provided by the dolphin monitoring program.

ACKNOWLEDGEMENTS

The authors of this workshop report thank the authors of the manuscripts and the workshop review panel for their efforts. We have tried to incorporate all comments received from both authors and reviewers on the text of this report. Any remaining errors are ours.

APPENDIX 1: WORKSHOP AGENDA

DOLPHIN SURVEY DESIGN MEETING
10-11 JULY 1990, SWFC, La Jolla, CA

AGENDA

TUESDAY, 10 JULY 1990

9:00 - 9:15 AM: INTRODUCTION (DeMaster)

I) MOPS PAPERS

9:15 - 9:30 MOPS ESTIMATES 1986-1990 (Gerrodette, Holt, Sexton)
the latest estimates from MOPS
- MS # 1

9:30 - 10:00 SIMULATION MODEL EVALUATION OF MOPS SURVEY DESIGN
(Edwards and Kleiber)
evaluation of MOPS effort levels for estimating
dolphin school abundance, using TOPS simulation
environments
- MS # 2

10:00 - 10:30 COFFEE BREAK

10:30 - 11:15 CHARACTERISTICS OF MOPS ANALYSES (Sexton et al.)
effects of school size definition, excluding small
schools, truncating at 2 nm, subdividing sightings
by species groups, and pooling or stratifying, ON
abundance indices from MOPS
- MS # 3

11:15 - 12:00 STATISTICAL POWER OF MOPS ANALYSES (Gerrodette)
estimates of MOPS power and projections for future
surveys
- MS # 4

12:00 - 1:30 LUNCH

II) TVOD PAPERS

1:30 - 2:15 SIMULATION MODEL EVALUATION OF TVOD ANALYSES
(Edwards and Kleiber)
problems with nonrandom searching combined with
nonrandom distributions of dolphins
- MS # 5

2:15 - 3:00 STATISTICAL POWER OF TVOD TREND ANALYSES
(Edwards and Glick)
power of extant abundance indices derived from TVOD
- MS # 6

3:00 - 3:30

COFFEE BREAK

Dolphin Survey Design Meeting, AGENDA, (continued)

3:30 - 4:15

SIMULATION MODEL EVALUATION OF CHARTER SUGGESTION
(Kleiber and Edwards)
would chartering the fleet be a useful alternative
or addendum to MOPS ?
- MS # 7

4:15 - 5:00

Group discussion

WEDNESDAY, 11 July 1990

III) RV/TV COMPARISONS:

9:00 - 9:15

INTRODUCTION, REVIEW (DeMaster)

9:15 - 10:00

SIMULATION MODEL EVALUATION OF DENSITY DEPENDENT
EFFECTS
(Palka)
effects of MacCall's Basin Model on estimates from
TVOD and RVOD
- MS # 8

10:00 - 10:30

COFFEE BREAK

10:30 - 11:15

DIRECT COMPARISONS OF RVOD AND TVOD
(Wade)
RV vs TV school size, encounter rate, and abundance
estimates, using MOPS and contemporaneous TVOD
- MS # 9

IV) ENVIRONMENTAL EFFECTS

11:15 - 12:00

ENVIRONMENTAL INFLUENCES ON DOLPHIN DENSITY
ESTIMATES
(Reilly)
implications of seasonal movements during survey
period
- MS # 10

12:00 - 1:30

LUNCH

V) SUMMARY AND DISCUSSION

1:30 - 2:00 Summary of major points (DeMaster)
2:00 - 5:00 Group discussion and recommendations

ADJOURN

APPENDIX 2:

Dolphin Survey Design Group:
Meeting Participants

1) Southwest Fisheries Science Center:

Jay Barlow
Doug DeMaster (Chairperson)
Liz Edwards
Tim Gerrodette
Cheryl Glick
Rennie Holt
Debbie Palka
Paul Wade
Steve Reilly

2) Inter-American Tropical Tuna Commission

Alejandro Anganuzzi
Martin Hall

3) Visiting Scientists:

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